# *Meso-machining:*
## *Bridging the Gap between Micro-and Miniature-machining*

***Meso-machining technologies being developed at Sandia National Laboratories will help manufacturers improve a variety of production processes, tools, and components. Meso-machining will benefit the aerospace, automotive, biomedical, and defense industries by creating feature sizes from the 1 to 50 micron range.***


*Sandia's Micro-Electro Discharge Machine (Micro-EDM) (above). On the upper right inset is the Micro-EDM electrode in copper that was made with the LIGA (electroforming) process. On the lower right inset is a screen fabricated into .006 inch kovar sheet using the Micro-EDM electrode. The walls of the screen are .002 inch wide by .006 inch deep.*

Sandia's Manufacturing Science and Technology Center is developing the following meso-machining technologies:

- Focused ion beam (FIB) machining,
- Micro-milling and-turning,
- Excimer and femto-second laser, and
- Micro-electro discharge machining (Micro-EDM).

These technologies complement Sandia's existing micro-scale technologies such as silicon-based micromachining and LIGA (electroforming). Meso-scale processes have different material capabilities and machining performance specifications. Machining performance specifications of interest include minimum feature size, feature tolerance, feature location accuracy, surface finish, and material removal rate.

Sandia's Manufacturing Science and Technology Center is pursuing partnership projects to further develop meso-manufacturing technologies that Sandia uses to help fulfill its important national security objectives. One such partnership involves working on micro-fabrication with Louisiana Tech University in an FIB project to ion machine micro-end mills and micro-turning tools. The FIB is capable of machining nano-scale features in a variety of metals.

In addition, Sandia is conducting research and development (R&D) to develop processes to manufacture parts in specialized materials and components that cannot be obtained either in commercial markets or through U.S. Department of Energy production facilities. For instance, work is being conducted to fabricate subminiature parts with non-planar features from engineering materials such as steels, kovar, plastics, ceramics, and rare earth magnets.

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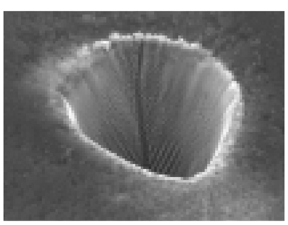
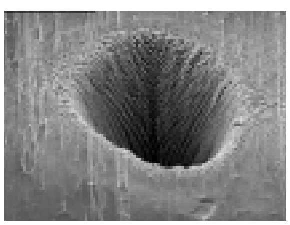
Sandia can machine both 2-D and 3-D, micron-sized features in such engineering materials as ferrous metals and ceramics. Our advanced meso-machining processes also can complement micro-fabrication in such applications as

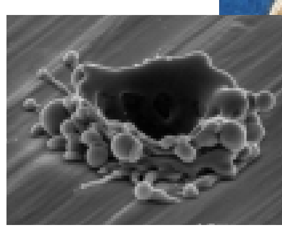
- Fluidic channels and packaging,
- Micro-cutters,
- Micro-valves,
- Particle filters,
- Subminiature actuators and motors, and
- Wafer slicing and dicing.

Sandia's Micro-sinker EDM is being used to extend the material base for LIGA. The LIGA process is used to fabricate subminiature, high-precision copper electrodes. The Micro-EDM uses these copper electrode tools to plunge into materials such as kovar or stainless steels. Our Micro-wire EDM is capable of machining with 25 micron diameter wire and has positional accuracy of ±1.5 microns.

Sandia is developing a femto-second laser machining workstation. This technology is capable of machining deep 1 micron size holes in a variety of materials with practically no debris. Femto-second laser machining has an impressive material removal rate while avoiding thermal damage.



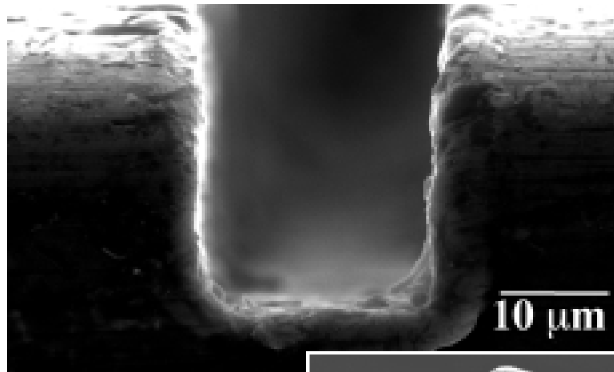




*In collaboration with pulsed power, these three photos show (left) a Ti sapphire system (120 femtoseconds) in air and (middle) in a vacuum. These are compared with (right) a hole drilled by an Nd: YAG laser ($\lambda$= 1.06 µm; pulse width = 100 nanoseconds, P = 50 mW, 2 kHz). All images were taken from the entry side of the kovar foil.*

Sandia's new research projects include blending silicon-based MEMS with meso-machining technologies. Computer-numerically controlled micromachines are relying on technical approaches that use

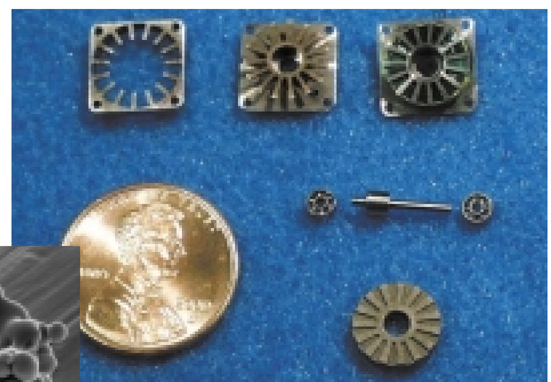
- Parallel mechanisms to achieve multi-degree of freedom micro-stage,
- Stepper motor/rack and pinion actuator for open loop control, and




*A 25-µm end mill tool (right), with five cutting edges, was fabricated using focused ion beam machining. The end mill was used to make this 25-µm wide x 25-µm deep channel (above) in aluminum.*

- Sputter deposition to apply materials (such as tungsten carbide or titanium nitride).

Also, electromicrofluidic packaging is enabling a scale factor of approximately 1,000 that exists between small, standard fluidic connectors (microliters) and fluid channels on the silicon based electromicrofluidic IC (nanoliters).



*Meso-scale stepper motor machined by Micro-EDM process. Stepper motor size is 10 mm x 10 mm x 5 mm. The Micro-EDM enables high performance motors by machining difficult materials such as Neodymium iron boron and Hiperco® alloy.*

***For more information, visit the Sandia Manufacturing Science and Technology Center web site at http://mfg.sandia.gov/ or contact:***


*Gil Benavides*
*Sandia National Laboratories*
*Phone (505) 844-6308*
*e-mail: glbenav@sandia.gov*

*Alan Parker*
*Sandia National Laboratories*
*Phone: (505) 844-9472*
*e-mail: arparke@sandia.gov*